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THE MEXICAN COTTON-BOLL WEEVIL.

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., March 18, 1901.

SIR: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, the manuscript of a report on The Mexican Cotton-Boll Weevil, prepared by Prof. F. W. Mally, State Entomologist of Texas. The report deals with the methods found by him to be most practicable in destroying the pest, and which he recommends for general application. Actual tests upon large plantations are said to have proven the efficacy of the suggestions made by the author in affording relief from serious ravages by the weevil.

Very respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON,
Secretary.

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THE MEXICAN COTTON-BOLL WEEVIL.

(*Anthonomus grandis* Boh.)

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Size.—The full-grown weevils (fig. 1) vary in size from three-sixteenths to three-eighths of an inch in length. They are quite active when traveling, but fly rather sluggishly. The size of the adult frequently depends upon the food supply which the larva has had. The writer has known eggs to be laid into squares no larger than a small pea, and the small white larva would feed upon the contents of this until all was consumed, and then transform into the adult weevil of not more than half the normal size. This shows the adaptability of this pest to its food supply.

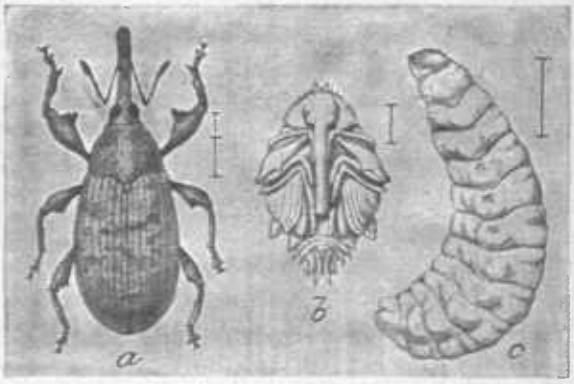

FIG. 1.—The Mexican cotton-boll weevil (*Anthonomus grandis*): *a*, adult beetle; *b*, pupa; *c*, larva—all enlarged. (After Howard.)

Color.—The color of the adult varies somewhat, depending upon the age of the weevil examined. A newly transformed weevil is whitish all over. As it gets older the body becomes chocolate in color. The wings at first turn a clear wine color and then darker, later becoming slightly hairy or pubescent. Down the middle of the upper surface of the thorax this pubescence becomes so dense and somewhat longer that it forms a whitish line. Some adults are found whose body color is essentially black instead of a dull chocolate. Again, some are more distinctly light brown. The pubescence soon wears off somewhat and then the weevils look darker. This accounts for the frequent confusion among planters as to what the genuine weevil is and how it looks.

Feeding period.—The active feeding period of the adult weevils is during the day. At night they travel and fly but very little. It has often been noted that a weevil observed in any particular square at sundown, is found within the identical square at sunrise unless disturbed during the night. During the vigorous growing season of cotton the weevils go about from plant to plant by short sluggish flights. They prepare for flight by getting out upon some exposed portion of the plant and then aimlessly fly in a direct line until another plant is struck. When cotton is knee high or more it usually happens that they fly only across to the next row before striking another plant, on which they alight. Their spread over the field is a slow process during this growing period of the cotton, and the egg-laying season of the weevil.

Early in spring when the adults come out from winter quarters they are voracious eaters and feed readily on any young cotton to be found. They feed for the most part by getting up among the developing leaf buds between the seed leaves, into which they eat, just as they do the young squares later. In spring, before squares are formed on cotton, the weevils often eat a small hole into the tender growing portions of the stems or branches. They have a habit of eating into these somewhat differently than when eating into a square under cover. It should be stated, by way of explanation, that the end of the stout, slightly curved snout of the weevil is provided with small, claw-like jaws, with which it actually eats a hole rather than bores it, as the popular notion is. When preparing to feed on any exposed portions of the plant, the weevil nearly always uses its sharp mandibles at the end of the snout to rasp the outer bark, so as to enable it to get hold of the ragged ends, which it then deliberately pulls off and lays to one side. After doing this it eats the tender portions underneath. This process is comparable to peeling an apple before eating it. This is not an invariable habit, but prevails in the majority of instances, and is important as bearing upon the methods of poisoning, to be discussed later on. As soon as squares are formed on the plants the weevils at once attack them and eat holes into them from behind the shelter of the involucre or ruffle. When hard pressed for squares to eat, small, and even large, bolls will be eaten into.

Early in the spring the weevils are very active and feed freely and extensively. In the fall as the hibernating season approaches they become more sluggish and feed much more sparingly. In spring, too, when they are disturbed, they "play possum" and drop off the plant readily. In the fall they take fright less easily, are slower to "play possum," and are less active in every way.

It has not yet been definitely established that the boll weevil will feed upon any other plant than cotton.

THE EGG.

When ready to deposit an egg the female eats the customary hole into a square, form, or boll, and hollows it out somewhat larger at the inner end. She then turns around, protrudes her ovipositor, or egg guide, into this hole and deposits the egg. As she finishes this process she seals the opening with a small drop of glue. This prevents ants and other predaceous insects from finding the egg. It also prevents rain and dew from starting decay from the outside. It requires fifteen to twenty minutes for the weevil to eat the hole for the egg, deposit it, and seal the opening.

The egg is elliptical and almost colorless. It hatches in two or three days after deposition, depending upon the weather, producing a very small, white, footless larva, which immediately begins feeding inside the square.

So far as yet observed the female will deposit her eggs nowhere else than in the young squares, forms, or bolls, and never promiscuously

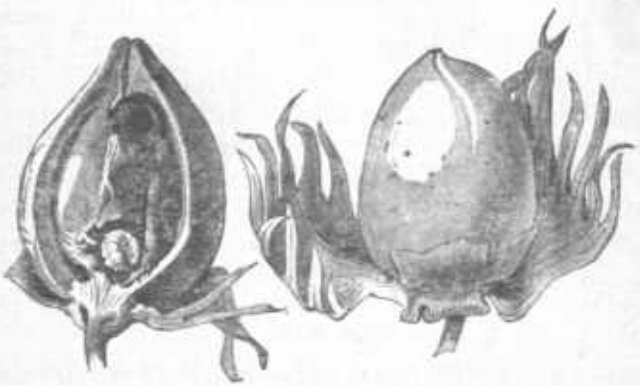

FIG. 2.—Mature boll cut open at left, showing full-grown larva; the boll at right is not cut, but shows feeding punctures and oviposition marks. (After Howard.)

over the plant. It sometimes happens that two eggs are laid into a square, but this is not common. Should squares or forms become scarce, the females attack the young, and even well-grown, bolls. When thus pressed for food it is often found that two or three, or even more, eggs are laid into the developing bolls.

Observations are not yet conclusive, but those made so far indicate that a distinct hibernating brood is produced late in the season in those sections where frost kills cotton. Few, if any, of the eggs of the females of this generation are laid in the fall. The eggs deposited late in the season are more likely, or mostly, eggs of belated females from the previous generation. If a distinct hibernating generation is not produced late in the season, the fact remains that the last brood deposits very few eggs before the end of the season during which it was bred.

THE LARVA.

The white grub-like larva hatched from the egg at once begins feeding on the tender inside portions of the square, form, or boll into which the egg has been laid. It feeds here for its entire life period, protected from all exposure. In full-grown bolls these larvæ are often found feeding inside the maturing seeds. The egg is occasionally deposited so late in the season that the larva barely has time to eat into the seed before the boll opens. Hence the cotton is sometimes gathered and ginned before the larva has become full grown, passed through the pupal stage, and issued as a weevil. It consequently often happens that adult weevils are found in the seeds later on. (See figs. 2 and 3.)

FIG. 3.—*a*, Newly hatched larva in young square; *b*, nearly full-grown larva *in situ*; *c*, pupa in young boll picked from the ground. (After Howard.)

It requires fourteen to seventeen days from the time of hatching for the larva to become full grown. It is a white footless grub, with a brown head. When full grown it is from a quarter to three-eighths of an inch in length, usually slightly curved or doubled upon itself.

THE PUPA.

When the larva is full fed it passes into the third or pupal stage. Here it transforms into a robust, short, compact form, showing the wing pads, legs, and snout. The abdominal end is free and is wriggled about very actively when disturbed. It is white until just a short time before the weevil is ready to come out of this pupal transformation state. Then it turns darker and the weevil escapes or hatches. The time occupied in this stage is seven to ten days. After the weevil leaves the pupal skin it requires a couple of days to color and harden up and to appear, as does the adult weevil already described under that heading. When fully colored up, the adult eats a small round hole out of the square or boll it has been in all its lifetime, and escapes to the open air.

It should be carefully noted that the egg is laid nowhere else than in the squares, forms, or bolls. The larva grows and matures inside these, and there changes into the third or pupal stage. This stage is also passed in the same squares, as also the first few days of the adult stage. This is important, as will be noted from the recommendations based upon it further on in this report.

HIBERNATION.

The adult weevils begin seeking winter quarters as soon as the first cold weather begins in the fall. They crawl into cracks and crevices under bark of posts and trees, and under all kinds of trash and rubbish on the farm, in the gin, seed houses, and buildings on the plantation. The partially opened bolls and cotton-stalk trash also afford hiding and shelter. The weevils therefore pass the winter in the adult stage, ready to come out in spring as soon as cotton planting begins. They come out as soon as the weather becomes warm enough, and from that time on until frost they are depredating on cotton.

There are often many eggs, larvæ, and pupæ in the squares and bolls when the first heavy frosts come. These all die from the effects of severe cold before spring. In fact, severe freezes alternating with warm spells will kill many of the full-grown hibernating weevils before spring. Only the full-grown insects have any chance of passing the winter.

MIGRATION.

There is much confusion as to the spread of this pest over new territory from year to year. Close observation concerning this problem has developed the fact that during the growing season for cotton the weevil spreads very slowly except under unusual conditions. The unprecedented high winds and storms of the season, culminating in the disastrous hurricane of September 8, 1900, which covered almost the entire weevil district, were largely responsible for the unusual spread over so much new territory in midseason that year.

As already stated, the weevils are sluggish in flight, and ordinarily fly no great distance at one time. As a matter of fact, they spread over new territory mostly in the fall, when frosts compel them to leave the cotton fields and seek winter quarters. That is to say, their hibernation march in the fall usually causes them to fly more continuously and greater distances in a few weeks than during the entire growing season.

Then, again, in spring, when warm weather brings them out, they also have a long chase in search of fields where young cotton may be found growing and ready to afford them their first food. Here, again, they spread over more territory in a few weeks than during the remainder of the growing season. Hence after the migration to new territory in fall and spring there is very little more spread unless there should be a scarcity of food.

It is important to note these facts carefully, because many planters fail to make war on the weevil for the reason, as they assert, that the weevil will spread to them from their neighbors who make no effort to subdue the pest. This idea is of course erroneous, in view of the fact that during the growing season there is little spread after the

hibernating weevils have all issued. Each planter will therefore receive practically the full benefit of all efforts made to control the pest whether his neighbors do so or not; but practically the same fight will have to be made each season, whereas if all cooperated, the pest would gradually, but certainly, be so reduced that the expense of making war on it would be lowered to a minimum.

DISTINCTION BETWEEN BOLL WEEVILS AND ACORN WEEVILS AND SHARPSHOOTERS.

The opinion is often expressed that the acorn weevil, so common in oak-timber sections, is identical with the boll weevil. Nothing could be a more prononnced error. The two are positively distinct species. The boll weevil will not attack acorns, nor does the acorn weevil attack cotton for food. The boll weevil flies sparingly at night, nor is it attracted to lights, while the acorn weevil flies freely at night at certain seasons and is readily attracted to lights. Failure to know and observe these differences accounts for the assertion made by some otherwise conscientious and reliable persons that boll weevils were caught by lamps. In all cases investigated, weevils so caught proved to be of the acorn and other species, not boll weevils.

Then, again, many assert that the sharpshooter is identical with the weevil under discussion. As a matter of fact, the insect properly called the sharpshooter is not even a weevil, but a leaf hopper, and feeds by puncturing and not by biting. Attention is called to these popular errors for the reason that some refrain from making war on the boll weevil because nothing is done against either of the other two insects mentioned.

EXTERMINATION OF WEEVIL BY CULTURAL METHODS.

Various methods have been practiced for the destruction of the Mexican boll weevil and for the treatment of infested cotton fields. Reference will here be made to the remedies found most efficacious by the writer as the result of his special investigation of the subject during the last two years, which it is hoped may be useful to the very large number of persons interested in the cotton industry.

LAMP TRAPPING.

The adult boll weevil flies little, if any, at night, and hence lamps will trap very few, if any, of them. Numerous tests have been made with specially designed lamps, which were so placed in infested fields that plants having squares with weevils resting quietly in them might be in the direct glare and light of the lamp. In no case did the light coax out the weevil from its quiet rest. This practice is entirely useless, and the time, labor, and money so expended are totally lost.

On the other hand, these lamps attract many beneficial insects, which aid us in destroying the harmful ones, and many hundreds of the former are trapped and destroyed. Thus, instead of being a benefit, this lamp trapping is a positive injury, and can not be too strongly condemned.

TRAP ROWS OF COTTON.

It was often noted that one field of cotton was badly infested, while one or more adjoining fields remained free for a long period. This fact emphasizes the statement previously made that the weevil spreads slowly to new territory once it finds growing cotton to feed upon. It further argues the advisability of everyone's fighting the pest regardless of what his neighbor does. Investigation established the fact that the fields infested with weevils so long in advance of the adjoining fields were the earliest planted and the first to offer food for the weevils emerging from their winter quarters and taking up the search for young cotton. In other words, this first cotton formed centers of attraction and concentration for the weevils as they appeared. The neighbors who planted later escaped the early attacks.

This suggested the advisability of testing the method of planting a few rows of cotton extra early, and of an early maturing kind, so as to uniformly trap the emerging hibernating weevils as they came to the fields. These few early rows planted some time ahead of the main crop serve to concentrate the pest on them. By treating them and making war on the pest on these few rows the work is not only more effective, but the labor and cost are also immensely reduced. Accordingly, in a number of instances trap rows were planted on plantations in the manner indicated to test the value of this method. The results exceeded expectations. The trap rows were the first to produce squares for the weevils, which quite uniformly confined their first attack and egg laying to these rows for some time after the main crop, which was planted much later, was up and growing nicely.

Just how long the planting of the main crop should be delayed after the trap rows are well started depends largely upon weather and local conditions. Each planter must manage that to suit his locality. The special point to be observed is to plant the trap rows as early as may be and give them as great a start of the main crop as is possible. Generally speaking, make sure that the trap rows are attracting the weevils before the rest of the crop is planted.

In answer to the question, Why not plant the entire crop early? it may be stated that there is no objection except that it makes a trap of the whole plantation and multiplies the expense of destroying the pest over the whole field, whereas the first early warfare against the pest might be confined to the trap rows.

The question may properly be asked, Where should the trap rows be planted? According to my observation, the first boll weevils in

spring are usually found about gins and seed houses. Hence it will be advisable to plant short rows of cotton near these places; also about houses, feed lots, and stock sheds, especially if the cattle have been fed freely on cotton seed. Trapping the weevils here prevents their spreading to the fields.

Timbered sections afford ample opportunities for the weevil to hide, and hence trap rows should be planted along the edges of the woods, alongside of or surrounding the cotton fields. (See fig. 4.)

For the field planting of trap rows it has been found fully satisfactory to plant a row or two across the middle of every 20 acres, or at that rate.

By giving careful attention to the location of trap rows many weevils can be congregated and destroyed before they reach the cotton fields.

Should the planting season be so unfavorable as to make it impracticable to properly employ the trap-row plan, then it will be especially advisable to resort to picking the cotton absolutely clean of all squares as soon as it is evident that all of the hibernating weevils have issued. Then follow this immediately with a thorough spraying, using the stronger solution recommended for the trap rows. Under these circumstances the weevils will be largely gathered and destroyed. At the same time those which escape being gathered, finding no squares, will be tempted to eat of the poison more freely, which will insure the greatest possible destruction of the pest.

FIG. 4.—Late fall boll, showing how beetles hide between the boll and the covering or wrapper. (After Howard.)

Treatment and management of the trap rows.—Once the weevils are congregated on the trap rows, advantage can be taken of their habit of of "playing possum" when disturbed or frightened. To profit by this habit, tests were made of a plan to use pans, and, bending the plants over them, to shake the plants vigorously, repeating this operation from plant to plant along down the row. The pans should be previously smeared on the bottoms and along the sides with coal tar or some other adhesive substance. Much depends on the operator. Careful inspection of the rows thus treated showed that from 60 to 95 per cent of all weevils on the plants could thus be shaken off. This work carefully done, when confined to trap rows only, is entirely feasible, also economical, and very effective. This shaking method becomes impracticable if an attempt is made to apply it to large plantations. For small fields of from 5 to 15 or 20 acres there is no more certain, economical, and effective method. It should be used for the trap rows especially, and for small fields.

FLARING OF SQUARES.

Planters readily recognize when boll weevils, or some insect affecting the squares similarly, are at work. They may discover their presence by what is called "flaring." This is an opening out and spreading down from the bloom or boll of the involucre, or shuck, exposing them. Yellowing of the affected squares follows the flaring. The squares affected soon ripen, as it were, and drop to the ground. This flaring and shedding is caused by the weevils eating holes into the squares and depositing their eggs. The simple eating off of the fruiting organs will produce the same result. This shedding should not be confused with the natural shedding of cotton, or with that caused by excessive rains following drought. Later in the season, when the weevils have become extremely numerous, there is one, or perhaps two, to every square produced by the plant. The preparation to flare and drop off begins at once after injury, and in most cases the blossoms never open. For this reason the remark is often heard that the boll weevil must be in the cotton because it does not bloom. It requires from one to two weeks to complete the flaring and dropping off of the affected squares. This is an important fact for the reason, as already stated, that the development of the adult weevil takes place within the square and requires at least twenty-five to thirty days for such transformation. If, then, the shedding occurs within two weeks after egg deposition, there will remain two weeks of lying on the ground, during which the life of the weevil is at the mercy of the planter. Of course, this does not apply when the squares become so scarce that the weevils are forced to lay their eggs into the boll. These do not drop, and this fact emphasizes the argument for determined action as early as possible in spring.

GATHERING THE FALLEN SQUARES.

It has been ascertained that the female deposits her eggs nowhere else than in the squares or young bolls. The infested squares flare and shed two weeks before the hatched larvæ can mature and escape. The female is limited in her capacity to lay eggs. Hence gathering up the fallen squares resulting from her egg laying and burning them must surely destroy the entire generation. Nothing can be plainer than that if this gathering and burning were scrupulously and persistently followed from the very first in the spring, the first generation of eggs would all be destroyed and the breeding for that season would be practically stopped.

The fact that the square lies about two weeks before the weevil can mature and escape makes it clear that this gathering should be practiced at intervals of ten to twelve days. This is of extreme importance for the reason that should squares lie long enough to allow

weevils to mature the gathering will have to be continued for the period of the second generation of females and their egg laying. Properly and scrupulously followed up, there should be very few shed weevil-infested squares to gather after the hibernating weevils have finished their egg laying.

It should always be borne in mind that as the cotton gets older the plant naturally sheds more squares, even though they were not ravaged by insect pests. Hence planters should not be discouraged with their success or results simply because squares continue to fall. The uninfested squares must be gathered at all times during the egg-laying season to make sure that no infested ones escape.

This method, as also the pan-shaking process, has often met with all kinds of ridicule, and has been dismissed by many as entirely impracticable. It is worthy of note, however, that this ridicule comes from those who have never tested the method. No one can deny the efficiency of these methods, and their value, therefore, hinges upon whether they are practicable and economical. Those planters who have only a small acreage have been the ones who during the past year have applied these methods most extensively. So far as tests among these small planters are concerned, there have been hundreds of them. The planters are all perfectly satisfied with the practical utility, economy, and effectiveness of these plans. Children can be employed to do this work of gathering. In this way many small cotton fields have been protected from the ravages of the boll weevil the past season by the industrious work of the children, and the farmer has had no perceptible extra expense.

Cost of gathering squares.—But it is the large planter who has a thousand acres under cultivation who stands aghast at the extensiveness of the task set before him. In order to secure actual figures and experience, tests were made upon these large plantations. In the trials adult negroes were employed, while as a matter of fact boys from 10 to 15 years could as well have been utilized. By actual test in this way it was established beyond question that for the months of May and June every fallen square can be gathered at a cost of from 5 cents to 10 cents per acre per gathering. When older, the cotton naturally sheds more and the expense for July may reach 25 cents per acre. When boys are employed the expense can be proportionately decreased. In the actual test an adult laborer easily gathered the squares from 15 to 20 acres per day during May, and from 10 to 15 acres during June. After that time the area gathered per day decreased to from 3 to 5 acres. Hence, early in the season with a squad of ten laborers a 1,000-acre plantation can be gone over each week if necessary at an expense of $60 per week, or 6 cents per acre. This certainly must appear economical to really thoughtful, practical minds. Many extensive planters have proven to their own satisfac-

tion the economy and practical utility of the gathering and burning process.

Furthermore, the adoption of the early trap-row strategy materially lessens the task. As heretofore stated, the adults in spring seek the early trap cotton and begin their ravages and their egg laying upon it. This confines the first gatherings of fallen squares to the few trap rows. The immense saving in labor is apparent and should appeal to every thoughtful planter.

PICKING OFF THE SQUARES.

A very effective method which can be resorted to with certainty of good results is that of actually picking off all the early squares which are produced before the cotton begins blooming. As has been noted, early in spring the weevils feed upon and among the terminal leaf buds before squares are developed. As soon, however, as these are produced the weevils take refuge in them and begin their ravages. As the squares are produced rather sparingly at first and the adults are found nowhere else, it is plain that practically the entire lot of weevils which withstood the winter may be collected and destroyed by this method, the important point being to delay this picking long enough to make sure that all living hibernating weevils have emerged. It is also important that this picking should be done early in the morning before the adults begin traveling in search of fresh squares for the day.

This method can be made especially effective upon the trap rows if they have been properly developed and managed. On these especially should it be resorted to in connection with gathering up the fallen squares, and to continue the war against the adults which escaped the pan-shaking method practiced before squares are formed.

This process involves a slight loss of squares intended for early fruiting, but the advantage gained in the greater certainty of eradicating the pest early, and the consequent immunity of the squares set subsequently, more than offset the slight possible loss involved.

PLOWING UNDER THE FALLEN SQUARES.

To avoid gathering up the fallen infested squares some planters practice plowing them under in the hope of destroying them. To ascertain the real merit of this process, specially designed cages were made, and adult weevils buried at various depths from 2 to 6 and 8 inches. The results uniformly showed that most of the weevils worked their way out from the shallow depths. This was especially true of the 2 and 3 inch depths, from which a healthy uninjured weevil rarely failed to escape. From a study of the actual cultivation and plowing operations in the open field it developed that by the ordinary sweep cultivation there could be no hope of plowing anything under to a greater depth than 2 to 3 inches. On black land soils especially will the depth

rarely be greater than 2 inches. As just noted, the weevils readily work out from these depths.

From a further careful field study it was noticed that not only did this shallow plowing under of the fallen squares fail to destroy them in most cases, but conditions were often such as to make this shallow covering of loose soil over them a positive advantage. In those sections where cotton does not grow rank, and permits the direct scorching rays of the sun to strike the soil between the rows, it was found that many fallen squares with weevil larvæ in them were so thoroughly heated that the larvæ perished. Earlier in the season the industrious little red ants are busily engaged in search for food and they often eat into the infested squares and destroy the larvæ or pupæ inside. Now if these squares be plowed under, the shallow covering of earth takes them out of reach of the friendly little ant, and also away from the scorching hot summer suns to a cool, moist place underneath. As soon as the larvæ mature in the plowed-under squares, the weevils which they produce find little trouble in coming to the surface and escaping. The process is therefore a positive injury under these conditions and must be condemned.

Conditions which afford shade, coolness, and sufficient moisture are ideal ones for the full development of the weevil. Hence, rank-growing varieties of cotton are not advisable, since on the rich bottom lands, where moisture is better conserved and cotton grows so rank as to completely shade the ground, the weevils are more plentiful and destructive than in the prairie and uplands.

RATE OF INCREASE OF THE BOLL WEEVIL.

Many planters are often indifferent to the boll-weevil campaign in spring because so few are found in their fields. To indicate how great a menace a few in spring are to the crop later on, the accompanying tables have been prepared.

It should be remembered that the adult female lays from 50 to 150 eggs, and that a complete generation is developed at least once each month.

The estimate of the bolls and squares per plant per acre is based upon cotton planted 1½ feet apart in the row and the rows 3½ feet apart. Upon that basis there would be, to use round numbers, 8,300 plants per acre. The squares indicated for each succeeding month are estimated as being in addition to those already produced.

In making up these tables, only a pair of weevils is taken into account, for the reason that very early in the season the weevils are so few and so scattered as to make it difficult to find them on the very small cotton. In fact, at the beginning of the season, not more than two or three weevils can be estimated for every 2 or 5 acres.

The amount of injury is estimated upon actual observations of the

feeding capacity of the adults, namely, that each adult weevil will attack at least one square each day and injure it sufficiently to cause it to fall. In the amount of injury is included that resulting from the feeding of the males for only one month, for the reason that they are short lived and doubtless die within that time. Account is taken of the feeding of the females for two months, since all evidence indicates that their egg laying is finished by that time and that they die soon after.

The rate of increase is estimated upon an egg-laying capacity of fifty eggs per female, which is the minimum rate so far as yet ascertained.

It should be stated by way of precaution that these tables are not to be taken as absolutely correct. They are only approximate and submitted to enforce the argument in favor of securing early fruitage in the cotton planted, and to show that this advice is based upon principle and not on opinions.

Table 1 shows what numbers will be attained if a pair of weevils is left to breed unchecked by any methods of warfare.

TABLE 1.—*Increase of Mexican boll weevil if left to breed unchecked.*

Month	Number weevils per acre.	Squares eaten per month per acre.	Squares produced per month per acre.	Uninjured squares left per month.	Squares produced per plant per month.
May 1	2	60	8,300	8,240	1
June 1	50	1,500 *a* 30	41,500	39,970	5
		1,530			
July 1	1,250	37,500 *a* 750	83,000	44,750	10
		38,250			
August 1	31,250	987,500 *a* 18,750	249,000	.....	30
		956,250			
Total *b*	.....	.....	.....	92,960	46

a Number of squares injured during the month by females left over from previous months. This is half the entire number for that month feeding at the rate of one square per day. This note also applies to Table 2.

b The total of uninjured squares is for July 1, while that of squares produced per plant is for August 1.

Table 2 is the rate of increase based upon the supposition that one-half are destroyed by applying the methods recommended for protecting the crop. This is a minimum result which might be expected from any kind of successful warfare, and is submitted simply to further illustrate the advantage gained from determined effort, also the importance of the use of early-maturing or early-fruiting varieties of cotton.

TABLE 2.—*Increase of Mexican boll weevil when one-half are destroyed by application of methods recommended for destruction.*

Month.	Number weevils per acre.	Squares eaten per month per acre.	Squares produced per month per acre.	Uninjured squares left per month.	Squares produced per plant per month.
May 1	2	60	8,300	8,240	1
June 1	25	750 *a* 30 780	41,500	40,720	5
July 1	300	9,000 *a* 360 9,360	83,000	73,640	10
August 1	3,750	112,500 *a* 4,500 117,000	249,000	132,000	30
September 1	46,875	1,406,250 *a* 56,250 1,462,500	415,000	.....	50
Total *b*	.....	.....	.....	254,600	96

a Number of squares injured during the month by females left over from previous months. This is half the entire number for that month feeding at the rate of one square per day.
b The total of uninjured squares is for August 1, and that of squares produced per plant is for September 1.

NORTHERN-GROWN COTTON SEED AND EARLY-MATURING VARIETIES.

Attention has already been called to the advantage of securing squares on the plants as early as possible in order to confine the egg laying and the gathering of infested squares to the trap rows. This is easily accomplished either by planting cotton seed grown in a latitude as far north as practicable, or by planting extra early fruiting and maturing varieties.

There is another important reason why the same principle should be adopted in selecting the seed to be used for the main crop, planting of which follows the trap rows. From Table 1 it can be noted under rate of increase that it requires the early portion of the season up to midsummer for the weevils to breed and become numerous enough, even if given full sway, to produce one weevil for each square that the plant can produce. It is well known in the Brazos and Colorado river bottoms that home-grown seed produces plants whose tendency is to make a large and vigorous growth early in the season and to set its crop of bolls later. Hence, it does not begin setting much fruit until July, which, according to Table 1, is the time when the weevils have become numerous enough to prey upon each square as it is produced. Extra early varieties, or the same varieties with seed obtained from farther north, begin fruiting freely three weeks to a month sooner, and set a fair crop of bolls beyond the reach of boll weevils previous to the month of July. Seed from Indian Territory planted in the Colorado River bottom in Colorado County, Tex., has been observed to set fully enough bolls for one-half bale per acre by the middle of

July, before boll weevils had become numerous enough to cut them off. After this time the growing plant continues producing new squares until frost, and the weevils finding ample food in them, allow the bolls set before that time to escape attack. This is upon the basis of giving the boll weevil full sway.

If any serious effort is made to gather and burn the infested squares the danger season will be postponed until the end of August, which will insure practically an average crop. Table 2 is estimated upon the basis that only one-half of the breeding of the pest for the season is destroyed. Even upon this basis a study of the table makes it evident that the month of August is clearly placed on the safe side of the danger line.

But no such poor results follow methods heretofore recommended (trap rows and gathering), and practical immunity can be insured if proper effort is made.

FUMIGATING INFESTED COTTON SEED.

The fact that cotton seed produced in the weevil district has a tendency to make a large plant growth before beginning to set bolls is not the only objection to be urged against its use. In discussing the life history and habits of the weevil, it was noted that many were gathered along with the seed cotton carried to the gins, the cotton ginned, and the weevils escaped destruction by coming out with the seed. The first beginnings of weevil infestations are often directly traceable to the cotton seed bought for planting purposes from badly infested sections. The seed should, therefore, be treated as it is ginned and stored. For this purpose use a pound of carbon bisulphide for every 25 to 50 bushels of seed. Sprinkle it freely over the seed as the bins are being filled, and repeat the operation frequently. The fumes are heavier than air and will permeate downward. When the bin is filled, close all the openings securely.

VOLUNTEER COTTON.

The cultural methods advised thus far apply more especially to those districts where the seasons of the year include severe, or at least killing, frosts. In those sections where cotton stalks do not die, or are only killed down to the ground, the methods suggested are not so applicable. The method of grazing hereinafter discussed is especially applicable to such sections, and early spraying, also to be discussed later, becomes an important factor.

At this time, therefore, there seems to be no reason why volunteer cotton culture should be condemned where that system is practicable.

It should be remembered, however, that any method to be successful must be accompanied with the gathering and burning of the squares. The pan-shaking method at this time seems feasible and practicable only for the trap-row system properly developed.

GRAZING OFF THE COTTON.

During midsummer there is little which can be done practically or economically, and if methods of warfare are not applied early in the season the unfortunate planter must be satisfied with the fruits of his negligence, and resolve to begin the fight promptly with the next crop. As the fall season approaches there is an extremely important move to be made. It is well known that cotton keeps on growing and producing squares until severe frosts cut it down. It is also well established that squares which do not bloom within six weeks of frosts have but little chance of maturing fruit. The immense crop of squares produced during this period serves no other purpose than that of food and places for egg laying for the great numbers of weevils which have developed. These facts put us face to face with the problem: How to dispose of these squares and destroy the weevils, and at the same time lose as small a quantity of maturing bolls as possible. This problem has been most happily solved by inaugurating the practice of turning in herds of cattle and grazing the cotton. The stock will eat the tender growing tips, where are found the young squares. These are the portions of the cotton first eaten. With them go eggs, larvæ, and adult weevils. There is practically no escape. The all-important point to note is that this grazing must be done before the first frost. The first danger of freezing starts the weevils out on their search for hibernating quarters, and they gradually leave the cotton. The fact that the weevils are yet in the cotton when grazing begins makes it impossible for many to escape. The boll weevil fight can be won by practicing this grazing process thoroughly. One difficulty which sometimes arises is that occasionally a planter allows a heavy crop of crab grass to grow in his cotton fields late in the season. This is excellent forage, and when stock is turned in to graze the animals feed on the crab grass first, and but lightly upon the cotton until the former has been consumed. Clean culture is therefore essential to the greatest success of this method. If clean culture can not be maintained this grass should be set fire to and burned before the stock is turned in. This rubbish affords winter protection to the insect enemies of the cotton, and in any case should be burned on general principles.

Another difficulty in securing a general acceptance of this method lies in the fact that there is a small percentage of immature bolls which might yet open, but which the stock eats. Again, the scarcity of pickers sometimes results in the planters being far behind with their picking. This is the planters' misfortune and not the fault of the method suggested. Much depends on their management along this line. As for the small quantity of immature bolls which the stock eats, their loss, when contrasted with the benefits derived in the way of practical immunity from weevil attack for another crop, must seem too insignificant to seriously militate against the general application of

the method. This practice comes as near being absolutely eradicative in its results as any that has been tried. Just in proportion as it is applied will the cost of the weevil campaign in spring be diminished. Its application costs nothing, for, as a matter of fact, it is applied at a time when pastures are short, and so far as the stock is concerned, the practice is of positive advantage. There is one precaution to be observed, and that is to make sure that a good drenching rain has followed the last application of any poisons to the cotton. If such has been the case, there is positively no danger to the stock from grazing it.

TRAPPING THE WEEVILS INTO HIBERNATING QUARTERS.

After the cotton stalks have been divested of foliage and squares by grazing, they should be pulled, cut down, or plowed out, and piled in windrows across the field and allowed to remain to dry thoroughly. If any weevils have escaped the grazing process, they will collect in this rubbish for hibernation instead of going out to the timber and rubbish along fences, highways, and byways. In this manner the escaping weevils are actually trapped into hibernating quarters just where you want them. When this has been accomplished set fire to the windrows and burn up stalks, rubbish, weevils, and all. This method, coupled with that of grazing, as outlined, can have no other result than practical eradication.

It should be stated that allowing the stalks to remain standing during the winter and then gathering and burning does not have the desired effect, because the weevil does not and can not utilize them for protection while thus standing, and hence goes elsewhere for shelter. For this reason, also, windrowing the stalks after frosts does not have the desired effect, since it does not act as a trap during the period when they are seeking winter quarters. Previous to windrowing the cotton stalks, corn and stubble fields should be burned; also anything else which could afford the weevils protection. Just how to proceed with the labor of windrowing the stalks must be a matter for each planter to determine.

As soon as possible after all rubbish has been burned, the fields should be plowed as deeply as practicable, for two reasons: (1) To plow under and destroy all the squares and rubbish yet on the ground makes it impossible for any larvæ to mature and produce weevils; (2) it breaks up the cells in which the bollworm transforms during winter, thus destroying them also.

IS THE BOLL WEEVIL MIGRATORY?

The above question is suggested by the fact that the cotton-growing territory of the State invaded by this pest from its first spread across the Mexican border is now practically free from it. This freedom is coupled with the idea in the minds of the planters that the weevil

infests any given locality only for a time, and then disappears or migrates. Though not solved in all its details, much light can be thrown on this problem.

As has been previously indicated, the weevil thrives best and breeds most freely under conditions of liberal, though not excessive, humidity, accompanied by plenty of shade for the ground. The latter is afforded by the rank-growing cotton of the rich bottom-land sections. Such conditions are normally and essentially lacking for the greater portion of the supposedly immune territory in question. The weevil had been introduced and had attracted much attention in some portions as early as 1893. With normal rainfall from that time until 1895 and a portion of 1896, the pest multiplied rapidly and made such havoc on the cotton crop of southwestern Texas as to practically destroy it.

With 1896 began a period of drought and much distress among the farmers and cattlemen. Rainfall for this territory being rather limited at best, was even less abundant for the year 1897, when an unprecedented drought afflicted Texas generally and that section particularly. The year following was still considerably below normal in rainfall, thus making a series of three years of drought. The soils for the most part are sandy loams, and under the climatic conditions mentioned the plant growth of cotton was very greatly reduced. The conditions of drought made the rays from the scorching hot sun all the more penetrating and heated the light sandy surface of the soil to an unusual degree. One could hardly walk over it with bare feet. Hence two important conditions—shade and moisture—favorable to the weevil, were lacking. In addition, many thousands of the fallen squares became so heated while lying on the ground that the larva in them perished.

The conditions which make a scant plant growth for cotton also cut short the range for grazing. They have the further effect of maturing the bolls set very much earlier than usual. This resulted in the crop being gathered correspondingly earlier, with a few immature bolls remaining. Under these conditions the farmers and cattlemen, in the extremity of their distress, gathered in their cattle and grazed off the foliage and every tender portion of the cotton. As has already been outlined, no practice could have been more eradicative in its tendency; and, though not intentionally, the planters and cattlemen contributed most materially to the practical extermination of the pest within their borders. The three successive years of drought led to the quite general establishment of this grazing practice, and if the farmers and stock raisers of that section will only maintain it they have little to fear from the boll weevil.

It would therefore seem that the weevil was practically eradicated through force of circumstances rather than that the pest migrated *en masse*. It also suggests that, should there come a period of unusual rainfall for a few years in the territory now free from the pest and

the beneficial practices outlined be neglected, it would only be a question of sufficient time during which to breed when the crop in that section would again be ravished as seriously as ever.

What has been stated practically answers the second question negatively. In the sections of abundant rainfall, rich soil, and luxuriant growth, furnishing ideal conditions for breeding, there is no ground for hope that the boll weevil is likely to leave us.

DIFFICULTIES OF PRACTICING CULTURAL METHODS.

The real secret of the temporary unpopularity of the cultural methods lies in the baneful peculiar labor and tenant system in vogue among land-owners and planters. Often a planter goes to his plantation and outlines the steps to be taken to control the boll weevil. Immediately a cry comes up from the tenants who rent the lands that this is extra work and that they should be paid wages for gathering up the squares from the acreage which they are renting. The trap rows require a little extra labor and headwork, and both are burdensome to the average tenant. Unfortunately, in 95 per cent of the cases the planter has already "furnished" his tenant, so that he is compelled to keep him and have him grow some kind of a crop to reimburse him, at least partially.

In the fall, when it comes to utilizing stock to graze off the cotton and the weevils with it, the tenant again raises the objection that he has made what little crop there is and is unwilling to lose the chance of a few more bolls ripening. The tenant oftentimes has already decided to try another plantation the next year, and he is determined to give every boll a chance to mature. This changing about delays operations at the very time when active warfare should be waged.

This further explains why the small landowner who does his own farming, and as a rule has his own labor, has not raised a voice against the methods herein recommended. On the contrary, he is quietly practicing them with marked success in all parts of the weevil-infested district. Contrast this with the tenant who is in debt to the planter, is furnished from the plantation store, and who is bent on getting as much return for as little labor as possible.

For these reasons it is easy to understand why more numerous complaints have come from the large plantations only, and why their losses and damages have been so great. With no absolute control over their labor and farm management except for the season of one crop, instead of continuously from one crop to the next, there can be no other result. These unfortunate conditions are not subjects of investigation for the entomologist. It is his sphere to discover ways and means of relief which are practical, economical, and effective entomologically speaking. The problems of labor, tenants, and the industrial conditions must be met and mastered by the planters themselves.

TRAP CROP FOR THE BOLLWORM.

Some planters have objected to the trap-row system, which delays the planting of the main crop, for the reason that if delayed the crop will lose what has been gained over the boll weevil by a greater attack from bollworm later in the season; in other words, they insist upon getting in the whole crop as early as possible. In this connection attention is called to Bulletins Nos. 24 and 29 of the Division of Entomology, United States Department of Agriculture, which discuss the trap crops to control bollworm ravages. Briefly stated, they are about as follows:

Corn, both in bud and roasting ear, is the first-choice food plant of the bollworm. Cowpeas rank second. It is generally conceded that no extensive or serious damage is done the cotton by the bollworm until about the time the corn crop matures. This is due to the fact that corn has gotten too hard, the stalk has ripened, and the female moths are compelled to go to cotton. For this reason a few trap rows of corn are planted, using the genuine midseason Mexican June corn. This must be planted late enough in the season so that it begins making roasting ears about the time the main crop has fully hardened. The female moth is attracted to the trap corn and deposits her eggs on the silk and roasting ears, and the cotton escapes. To make doubly sure, cowpeas are planted between the corn rows at a time to make them begin blooming shortly after the main crop of corn has ripened. These pea blooms form a great attraction for the female bollworm moths. This compels the breeding and feeding of the midsummer brood of bollworms on these two trap crops. The brood next following this is thereby thrown too late in the season to do any serious damage to cotton. In fact, when the bollworms are thus crowded from hundreds of acres of corn into a few trap rows, they become cannibals and feed upon one another in the overstocked roasting ears of the trap rows. For that reason, also, there need be no fear of a serious attack later.

It has already been urged that early maturing varieties of cotton be planted, or seed from as far north as possible, so as to induce earlier fruitage. This gain in time of fruiting more than offsets the delay caused by withholding planting, on account of the trap-row system. The midsummer brood of bollworms being trapped, the cotton will suffer no greater attack from them than it would ordinarily have been subjected to had the home-grown seed or late-fruiting varieties been planted as early as possible.

EXTERMINATION BY SPRAYING.

There has been a great demand for remedies—poisons and boll-weevil machines. The distressed planter, accustomed to the use of poisons and some kind of machine in his warfare upon cotton insects, at first seemed bent upon being satisfied with nothing less.

SOME ERRORS IN SPRAYING.

It should be remembered that the weevils do not eat exposed surfaces of the plant, their almost invariable place of feeding being in the squares, safely sheltered by the involucre or shuck. Even here they

do not feed upon exposed surfaces, but eat a small hole to the inside and feed on the inner portions. In the spring, before squares are formed, they feed, when driven by necessity, upon almost any portion of the plant, but almost invariably the outer bark is first rasped and peeled off before feeding underneath. On account of this peculiar habit, it is at once evident that poisons and powders, either sprayed or dusted upon the plants, can be of little or no service, because the surface on which they are found is taken off and thrown aside. Another grave error relates to the manner of spraying. Practically all designs for spraying apparatus which are at all adapted for use on field crops are modeled upon the principle of horizontal supports for the spraying nozzles. Many of these machines have been tested and found useless, and for the following reasons: The cotton plant has a tendency while young to make a large plant and profuse leaf growth. The leaves overlap in such a way as to offer a more or less unbroken surface, protecting everything underneath. Hence spraying from horizontal supports downward over the plants would reach and cover only the upper surface of the leaves. The solution applied also has a tendency to run off like water from a duck's back. When the weevil travels in search of squares it crawls on the stems and limbs, rarely if ever getting upon the top of a leaf. These stems and squares being largely protected by the foliage overhead, the cotton may be thoroughly drenched in the ordinary way and yet the weevil may safely go about its business without ever coming in contact with the sprayed surface. The folly of this kind of spraying must therefore be apparent.

Spraying against boll weevils has been brought somewhat into disrepute by recommending remedies which, in themselves, may be efficient, but failing at the same time to devise and advise the proper apparatus with which to apply them.

SUCCESSFUL SPRAYING.

The errors just pointed out indicate the conditions under which spraying will be successful. As the weevil eats its food in a manner that it can not be made to eat poison along with it, the problem then is: Can it be induced to eat poison when presented in the form of a food itself? The fondness of most insects for sweets is well known, and the weevil is no exception. It has been ascertained that the pest is fond of cane or sorghum molasses when applied to the cotton. Hence, if any suitable poison in soluble form be included with this molasses the weevil will be poisoned and fall a victim to its appetite for sweets. Experiment has definitely proven in practice that the weevil accepts the poisoned molasses and is destroyed.

To reach the stems and the squares over which the weevil travels, the spraying must be done at right angles to the vertical axis of the

plant, with nozzles distributed vertically instead of horizontally. Actual field tests have proven that with this kind of an adjustment the main stalk, all the side branches, the small stems, and the squares can be thoroughly covered with the poisoned molasses solution. This spreads an inviting feast before the weevil wherever it travels about on the plant. Its fondness for sweets induces it to eat and its death is the result.

SPRAYING MACHINES.

The kind of apparatus to use will depend largely upon the acreage to be treated and the season of year when the spraying is to be done.

(1) Knapsack sprayers for trap rows and small acreages.—For the farmer having 10 to 20 acres of cotton there is no more practical apparatus than the knapsack sprayer. It holds about 3 gallons, and is provided with leather straps which fit over the shoulder. When filled, the workman takes the machine on his back. The pumping is done with one hand while the nozzle is held to the plant with the other. The operator should have an extension cane with an elbow for the nozzle. This will enable him to direct the spray most successfully to all the inner portions of the plants.

Spraying with a knapsack machine is especially advisable in treating the trap rows. With the nozzle at the end of the extension cane, the spray can be forcibly directed into the whorl or leaf buds in the top of small plants. With this apparatus the spraying is done more perfectly on very young cotton than is possible with the larger machines. When the plants become larger the knapsack becomes impracticable. Ordinarily a good active workman can spray 10 or 15 acres a day when cotton is small, and proportionately less as it grows larger. For those having their own labor and only a small acreage in cotton these sprayers are the most economical.

(2) Aspinwall sprayers for large plantations.—When hundreds or thousands of acres are to be sprayed, the knapsack, spraying 10 to 15 acres per day per machine, is too slow a process. If enough machines were bought and a sufficient number of laborers employed to do the work, it would be done quickly and efficiently. This, however, would involve a considerable demand for labor at a time when laborers are scarce or are badly needed for other work. To meet the conditions when large acreages are involved, a properly arranged boll-weevil attachment should be adjusted to the automatic sprayers. These machines are drawn by horsepower and do the pumping and spraying automatically as the team pulls the machine along. The vertical nozzle arms are adjusted and the nozzle attached so as to spray into the cotton plant as already explained. Results of tests with these machines have exceeded expectations, for no part of the plant escaped being well covered with the poisoned solution. One hundred acres can be sprayed per day per machine when cotton is small. When it gets larger more

nozzles have to be used. This requires more material and more frequent filling, hence a proportionally less acreage is treated per day.

For the large rank cotton of the river bottoms the nozzles must be adjusted to spray from the ground to the top of the plant. When cotton gets to be 5 or 6 feet high a long slender pole or iron pipe should be run in behind the whiffletree chains in front of the machine and crosswise of the rows. This catches the tops of the cotton and bends the plants over so that they are sprayed perfectly from underneath and for their entire length on stems and branches, as well as on the young growing tips, where the weevils are most plentiful.

LAYING OFF THE ROWS.

In order that the greatest success may be achieved with spraying operations, it is of prime importance that the rows should be laid off regularly and equal distances apart. This will be evident when it is remembered that a number of rows are sprayed at one time. If the nozzles are adjusted to spray rows thoroughly at a certain distance, it is evident that rows nearer together or farther apart can not be so well sprayed unless another adjustment of the nozzles is made. It is immaterial how great or small the distance between the rows may be, provided that distance be maintained uniformly throughout.

INGREDIENTS OF SPRAY.

The ingredients of the spraying solution should be mixed in proportions suited to the season and the conditions. In spring, before squares are formed, the weather is cooler and there is little danger of injury to the plant. Then, too, the exposed surface is smaller and a sweeter solution has been found to be desirable. Especially is this true for the trap rows. The proportions best suited for the trap rows and the first one or two sprayings of the main crop until squares begin forming, also for the later sprayings of the main crop, are given below:

Trap-row formula.

2 gallons cane or sorghum molasses.
2 ounces arsenic (90 per cent) boiled in a gallon of water until dissolved.
4 ounces arsenate of lead or disparene dissolved in a gallon of water
46 gallons of water. Mix thoroughly.

Main-crop or midsummer formula.

To be used on main crop as soon as squares are forming freely.
1 gallon cane or sorghum molasses.
1 ounce arsenic (90 per cent) boiled in a gallon of water until dissolved.
6 ounces arsenate of lead or disparene dissolved in a gallon of water.
47 gallons of water. Mix well.

The free arsenic is a dangerous poison to use on cotton when the plant begins setting squares, for the reason that its penetrating, scorch-

ing effect easily causes cotton to shed. This is especially true if the solution used is a trifle too strong in dissolved arsenic and its application is accompanied by the scorching hot suns of midseason. Hence, after squares are being produced, a lesser proportion of arsenic is used and the insoluble arsenate of lead is increased. The proportion of molasses is reduced, for the reason that, when the plants get larger, so much greater quantities of the solution have to be used per acre that the cost of the molasses becomes quite an item of expense. Then, too, the plant surface is larger, the weevil comes in contact with the sweetened bait more freely, and a lesser amount will answer the purpose. If, however, the planter makes his own molasses and has plenty, it will be advisable to use 2 gallons of molasses in each formula. Avoid using glucose or sirup, as they are inclined to gum and clog the nozzles.

The arsenate of lead, when thoroughly mixed with the molasses, causes the solution to adhere better, and tends to prevent its running off so readily in case of rains or heavy dews.

It is a poison and is itself rather sweet, so that, in addition to its adhesiveness, it increases the probability of poisoning the weevil. Heavy dews dissipate the dissolved arsenic too freely, and as the arsenate of lead is not soluble in water, it is more lasting, and has less tendency to cause shedding by its too free or frequent use in repeated sprayings. For this reason the quantity is increased in the midsummer formula.

WHEN TO SPRAY.

The fact that early in spring the weevil is compelled to feed more exposedly on young cotton makes it of the greatest importance to spray while that condition continues, or until squares begin to be produced. The cotton should therefore be sprayed once and thoroughly before the first squares are formed. Of course, the first spraying should be upon the trap rows. On these the sweeter solution should be used. For the first application to the main crop, the trap-row formula should be used, but as soon as squares begin to form freely on the main crop the second solution is recommended. In ordinary seasons, when the planter can work and plan with some certainty, there should be no occasion to continue spraying throughout the entire season.

It is to be noted that the cotton plant grows vigorously during the early portion of the year and midsummer. The increase in exposed limbs and surfaces, due to the new growth at the growing ends of the branches and main stems, confronts us with the proposition that a week after spraying the plant has doubled in exposed surfaces and foliage, and hence but half the plant is covered with the poisoned solution. The portion not covered is the young and tender part, which constitutes the choice lodgment for the weevil. Hence up to midsummer, while cotton is thus growing so rapidly, the entire fields should be

sprayed once a week, or until it is apparent that the weevil has been checked and is fully under control; in that case, or as soon as the cotton checks up in its new growth, the intervals can be extended to one spraying every two weeks.

CONCLUSIONS.

Without doubt spraying is effective and advisable if suitable poison solution can be prepared and then applied with suitable apparatus. However, it must be plain from the discussions in the foregoing pages that spraying should not be depended upon solely, but in conjunction with the cultural methods. Neither system used alone will attain the greatest efficiency. If either one is to be depended upon alone, the cultural methods are far more economical and efficient, and are capable of more general application under a greater variety of conditions. There can be no question of the desirability and the advantage of spraying, but it should be secondary, and should be practiced in conjunction with the cultural system.

Another reason for spraying is that the application of poisons makes sure of destroying all insect pests of cotton which feed upon its foliage. The careless worm (also called web worm) on cotton early in spring is completely destroyed. Then, too, the early scattering broods of the leaf worm, or army worm, are poisoned and all the tremendous expenditures for poisons and poisoning late in the season against these pests are largely saved.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress, or to the Secretary of Agriculture, Washington, D. C.:

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